

BELGIAN ACIDIC BEERS

DAILY WELCOME REMINISCENCES OF THE PAST



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Acidic beers

From (1) historic aspects
Through (2) biochemical aspects
To (3) technical aspects

Acidic beers

Historical aspects



6000 years BC ago, independent of regio's, it was discovered that



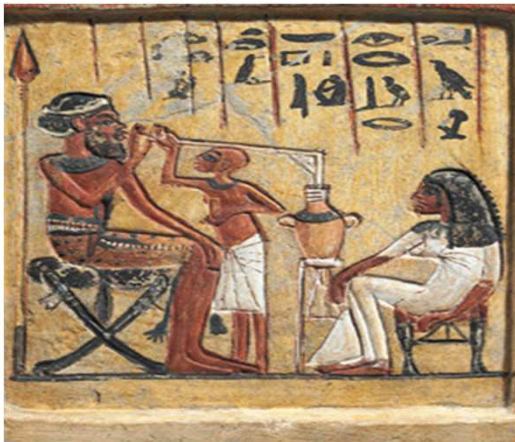
different tasteless milky suspensions of sugary material in water changed to enjoyable beverages on standing. The magic tool was spontaneous fermentation. Several types of "Beer" were invented. Soon however it was prescribed to consume it rapidly as a vinegar sourness already known from the souring of grape juice, started to dominate.

Acidic beers were invented. The souring must have been very common as known from texts such as "*..the dead pharaos were promised bread that doesn't crumble and beer that doesn't turn sour*".

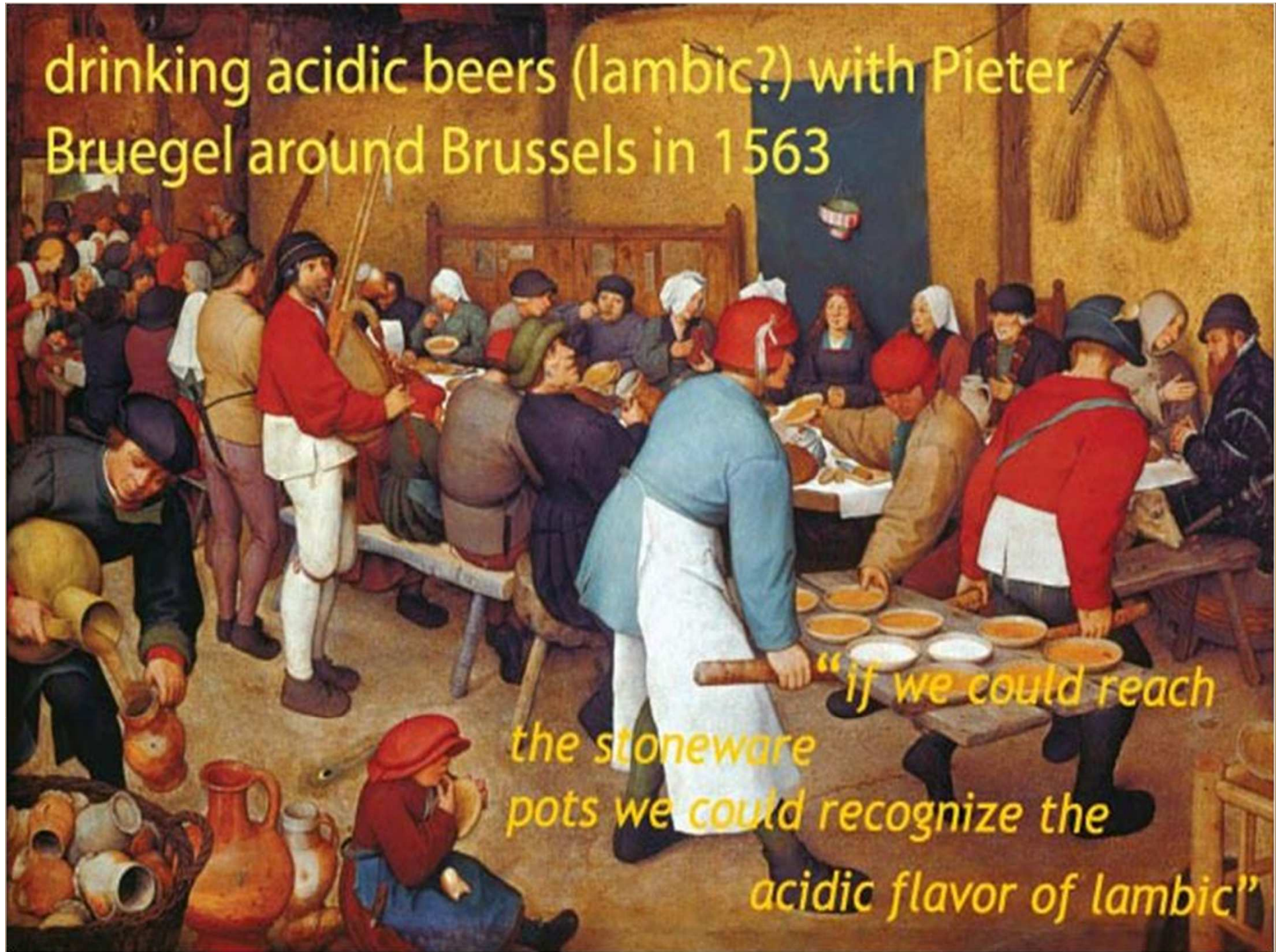


(acidic) beers from 6000 BC to 2012

**From reeds straws to drink the milky (acidic) beers
avoiding the deposits to cups,bowls,pots and...glasses**



drinking acidic beers (lambic?) with Pieter
Bruegel around Brussels in 1563

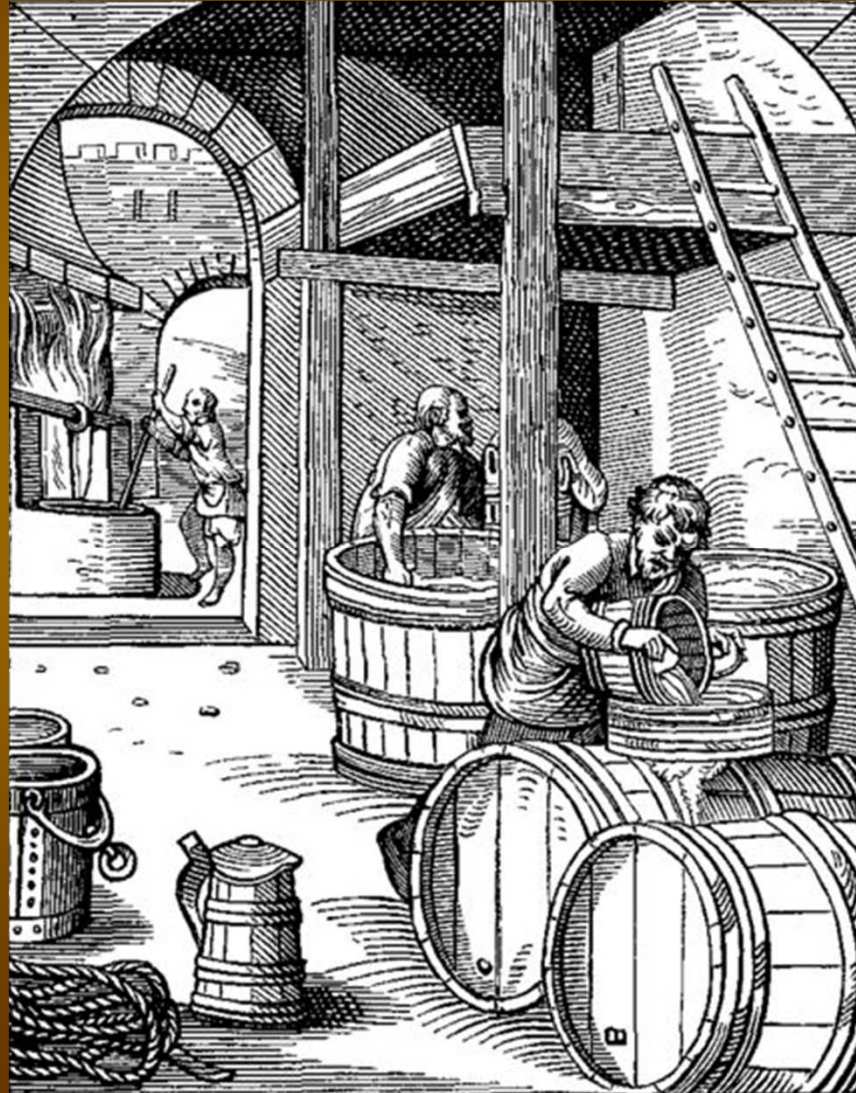


“if we could reach
the stoneware
pots we could recognize the
acidic flavor of lambic”

Peasant dancing and enjoying
more acidic beer



Medieval brewing



Acidic beers



**" A green wreath indicated
that the beer was fresh"**



ACIDIC BEERS AROUND 1560

**FERMENTATIONS QUASI SPONTANEOUS OR
WITH added FOAM "INOCULA" FROM PREVIOUS BATCHES**

LOW ATTENUATIONS and ALCOHOL CONTENT

THE BEERS ARE OPAQUE

UNAVOIDABLE BACTERIAL INFECTIONS FORM ACIDS

- **during wort cooling** (lactic acid)
- **during mashing - in** (lactic acid)
- **during storage** (lactic + acetic acid)

**INFECTIONS INTRODUCED FROM THE AIR, RAW
MATERIALS,EQUIPMENT and INOCULA**

Depending on region use of barley + wheat. Rye leads to "beer vinegar"

HOPS BETTER THAN HERBS AGAINST HIGH ACIDIFICATIONS

The famous beers of Louvain the Peterman and the Bière de Louvain (18th-20th century)

Peterman (yellow-brown)

Bière de Louvain (white)

barley + wheat

Acidity fresh beer 600 ppm (as lactic acid)

Old beer up to 4000 ppm

Alcohol :around 3 %

STATEMENTS CONCERNING BEER ACIDIFICATION AND WORT ATTENUATIONS (1895-1905)

" HIGH ATTENUATION LEADS TO HIGH ALCOHOL LEVELS WHICH KILL THE YEASTS, NEEDED DURING STORAGE TO FAVORABLY COMPETE WITH BACTERIAL INFECTIONS "

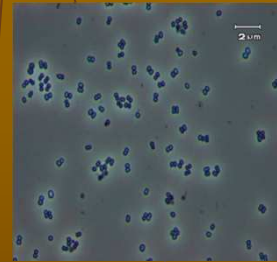
" HIGH ATTENUATED WORT CONTAINS RESIDUAL SUBSTRATES WHICH CAN ONLY BE USED BY NON-YEAST INFECTIONS "

CONSEQUENTLY KEEP THE ATTENUATION LOW :

- ❁ " TURN TO BARLEY KILNING OR RE-KILNING TO REDUCE ITS DIASTASIC POWER AND INCREASE THE FERMENTABLES CONTENT OF THE WORT "
- ❁ " USE THE TURBID MASH BREWING METHOD "
- ❁ " INCREASE WORT AERATION TO PRODUCE MORE YEAST AND REDUCE NITROGENOUS COMPOUNDS "
- ❁ " USE MORE NON - MALTED GRAINS "

Optimal lactic acid acidity of acidic beers advised by H.Verlinden (brewmaster in Brasschaat) around 1930 calculated from NaOH titration values

White beers of Louvain:	1800 ppm
Antwerp, Brabant, Limburg:	2700 ppm
Flanders beers:	4500 ppm
Lambics:	9000 ppm



Main Problem: how to control the concentration of acetic acid (bacteria)!!!

For lambics remain under the 1000 ppm limit.

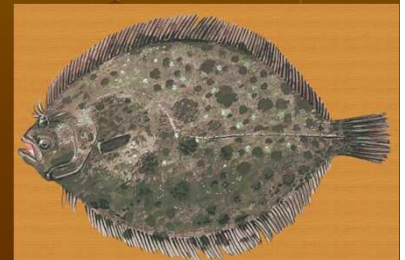
More old acidic beers in Het Hageland

Hoegaarden, Aarschot, Tienen,
Diest...

All involve a type of spontaneous fermentation in casks

Folklore : yearly « Grietmuyl » celebration in Tienen

« Grietmuyl »: Refers to the awful mouth of brill fish
(=griet=kind of turbot). Sometimes...
a drinker at a first sip of a Hoegaarden showed
a sour face... It indicated that the beer was
turning to vinegar, meaning the beer
was an acidic beer which
according
to indications had to be drunk before
summertime.



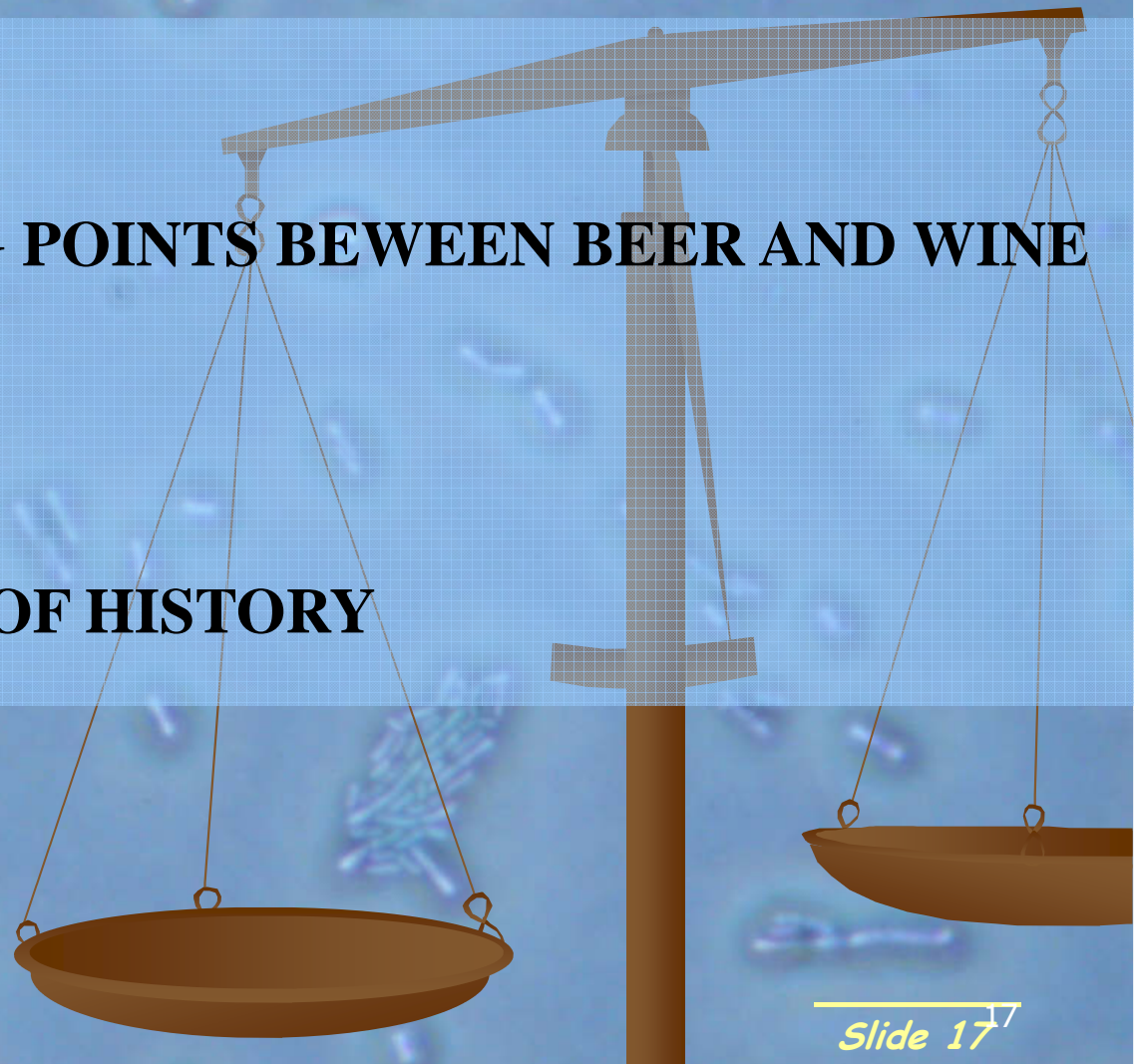
SPARKLING ACIDIC BEERS

AT THEIR BEST...

MEETING POINTS BETWEEN BEER AND WINE

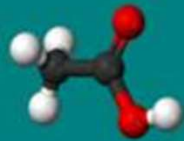
AT THEIR WORST ...

A TASTE OF HISTORY

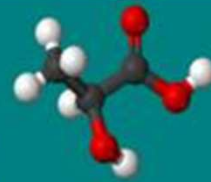


Acidic beers

Biochemical aspects



acetic acid and lactic acid
major causes of acidifications



1.Acetic acid

Centuries ago acetification= appreciated in many fermented foods



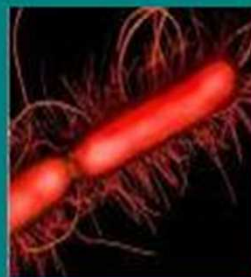
Acidity = of biological origin (Boerhaave, 1732)

Acidity is due to $\text{CH}_3\text{-COOH}$ (Adet, 1790)

Minute organisms are responsible (Kutzing, 1837)

small rods: type *Mycoderma aceti* (Pasteur, 1886)

Later named *Acetobacter* (Beijerinck 1899)



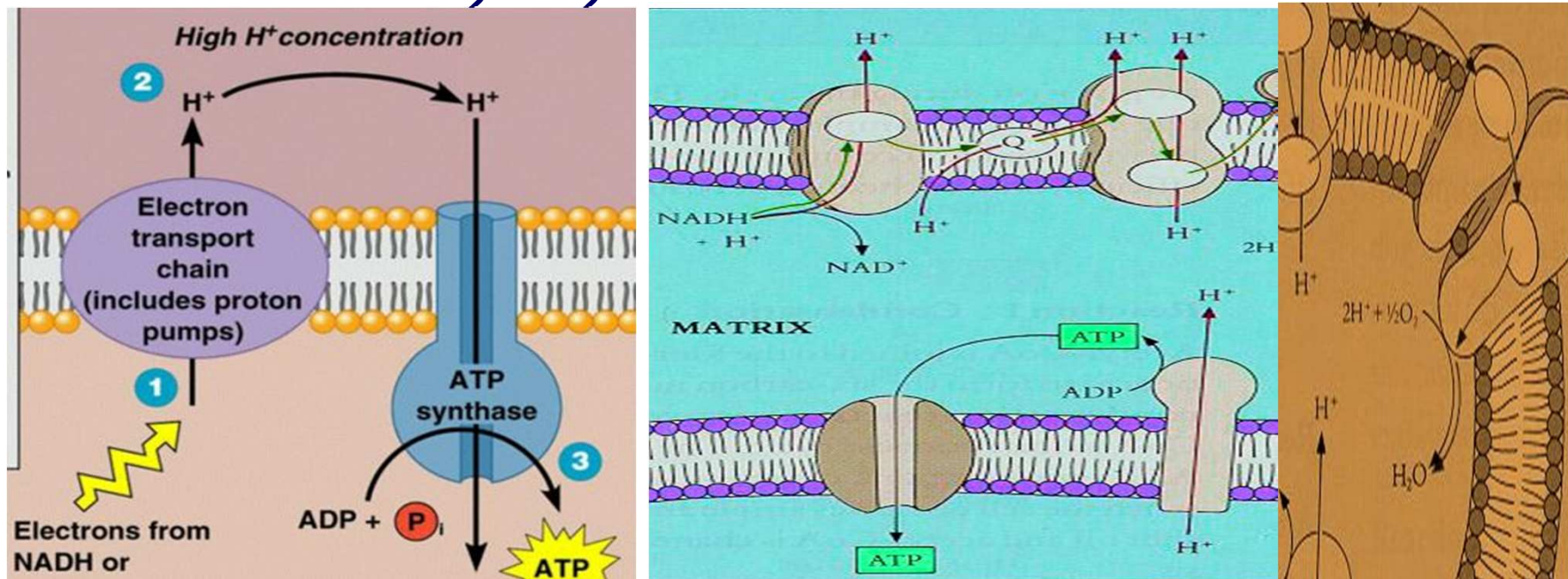
gram negative rods, obligate **aerobic**.

ACETIC ACID PRODUCTION from ethanol BY *ACETOBACTER* energy for growth=oxidation of ethanol with O₂ to acetic acid!!



Transport of electrons and protons from reduced co-enzymes to oxygen:

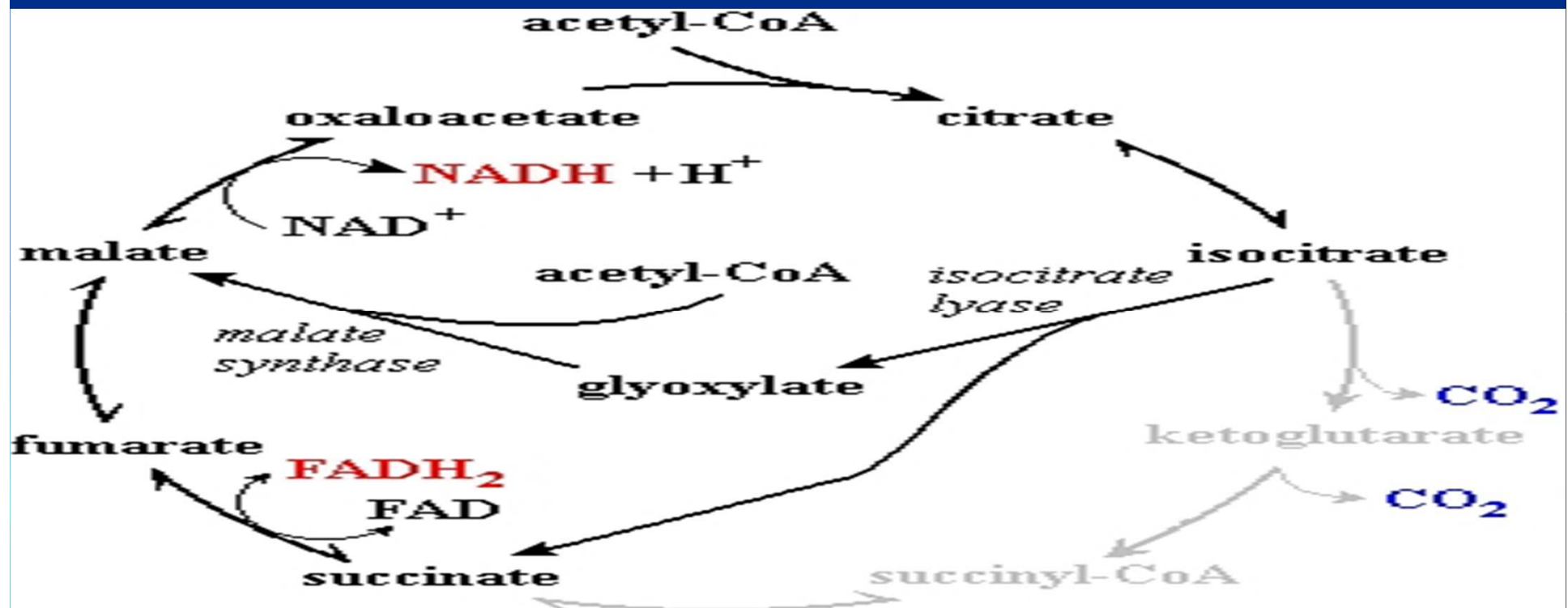
NADH >> electrons >>> O₂ >> H₂O + trans membrane proton gradient >> ATP synthesis



Growth on ethanol by *Acetobacter*

Growth = from ethanol through acetate and acetyl-CoA (c-2) and through malate (c-4) and the glyoxylate cycle

2 acetyl-CoA (2 C-2) \gg malate (C-4) + 2 CoA
then: malate \gg oxalacetate \gg pyruvate \gg sugars



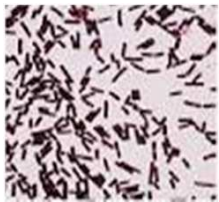
Unraveling the lactic acid acidification

Centuries ago: appreciated in milk, not in beer!

1780 Scheele: lactic acid isolated from milk

1873 Wislicenus: acid = $\text{CH}_3\text{-CHOH-COOH}$

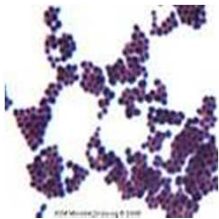
1876 Pasteur: acid = biological origin (rods + cocci)



1878 Lister: name *Bacterium lactis*



1892 Van Laer: *Saccharobacillus*



1901 Beijerinck: *Lactobacillus*

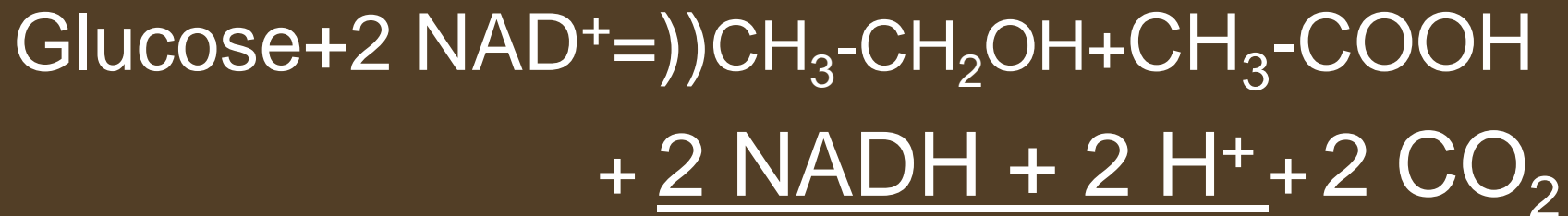


1812 Goodsir: Cocci *Sarcina* (latin = bundles)

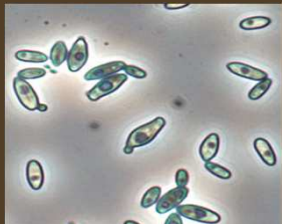
1884 Balcke: *Pediococcus* (latin cells in a plane)

Acetification by *Brettanomyces*

Brettanomyces: fermentation = stimulated by O₂
but leads to acetic acid !! (Scheffers, 1966)



Excess NADH stops further glucose metabolism



Oxygen regenerates needed NAD⁺

!!!! Fermentation resumes!!!!

Types of Belgian beers

- **Trappist ales (strong, with yeast deposit, brewed in abbeys)**
- **Abbey ales**
(strong, with /without yeast deposit, not brewed in abbeys)
- **Ales and strong ales (different colours, with/without yeast deposit)**
- **Pilsner types**
- **White beers (barley+wheat+spices,turbid)**
- **ACID ALES and FRUIT BEERS**

Acidic beers technical aspects

Belgian lambics
and gueuzes

Belgian acidic beers anno 2012

-2 main types-

1. spontaneous fermentation: *lambic*
and gueuze

2. yeast-bacterial mixed culture
fermentation



sparkling acidic beers

At their best...

*Meeting points between
beer and wine*

At their worst...

A taste of history

Where lambic and gueuze are produced (more recent :lambic types in West Vlaanderen:Ingelmunster and Bellegem)



LAMBIC : (*end 18 th century*) from **alambics**
found in breweries also making spirits

GUEUZE : gueuze = some old lambic sold in
bottles

- >>> with time bubbles and foam production observed
- >>> cheap used champagne bottles available (*begin 19th century*)
- >>> Champenoise method known and competition from sparkling new pilsner beers
- >>> improve lambic sparkling by blending old lambic with young lambic
- >>> good bottled lambic first sold in 1844 as gueuze-lambic by some breweries.

what's in a name?

Gueuze not mentioned in standard work of G.Lacambre in
1851

CHARACTERISTICS OF TRADITIONAL LAMBIC BREWING

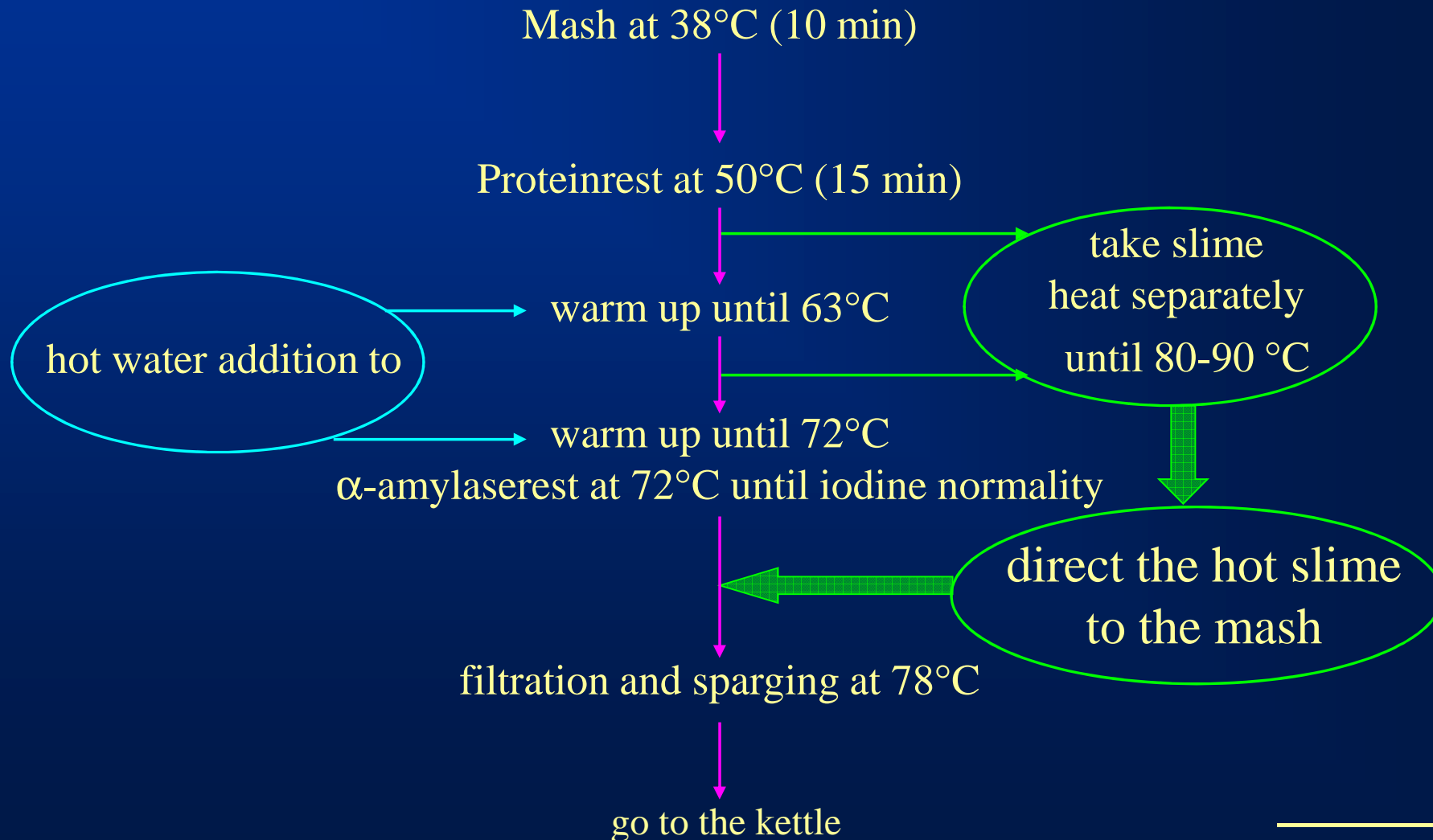
- ✦ RAW MATERIALS : BARLEY + *WHEAT*
- ✦ HOP : *AGED* HOP CONES / HIGH DOSIS
- ✦ BREWING: TURBID MASH
- ✦ FERMENTATION : *SPONTANEOUS*
- ✦ PRODUCTION : *COLD* SEASON
SELECTED REGIONS

Filling of open shallow trays





Turbid mash method (slijmmethode)



The so called madammen (madams)

A typical device of rotating perforated discs used by lambic brewers to filter the mash



Traditional gueuze brewing from bags of grain to glass



Wooden casks (300-8000 L) cask filling













Main lambic yeasts

- 1. *Saccharomyces* and typical ***Brettanomyces sp.***
- 2. Discovered in old English stock beer and named *Brettanomyces* in **1903** by Claussen (Carlsberg Laboratories)
- 3. Discovered in lambic in **1921** and named ***Br.bruxellensis*** by Kufferath and Van Laer
- 4. Gives typical **Brett flavour** consisting of e.g. ethylphenol, ethylguaiacol, isovaleric acid, acetic acid, ethylacetate, 2-acetyl 1,4,5,6 tetrahydropyridine and ethyllactate
- 5. Ferments higher oligo-saccharides !

Brettanomyces present in all
acidic beers ?

Prefer acidic conditions established by lactic acid
(and acetic ?) bacteria

Actually **5 Species**

Br.bruxellensis,intermedia,intermedium,lambicus,custersii

=***Brettanomyces (Dekkera)bruxellensis***

Br.abstinens,claussenii,anomalus

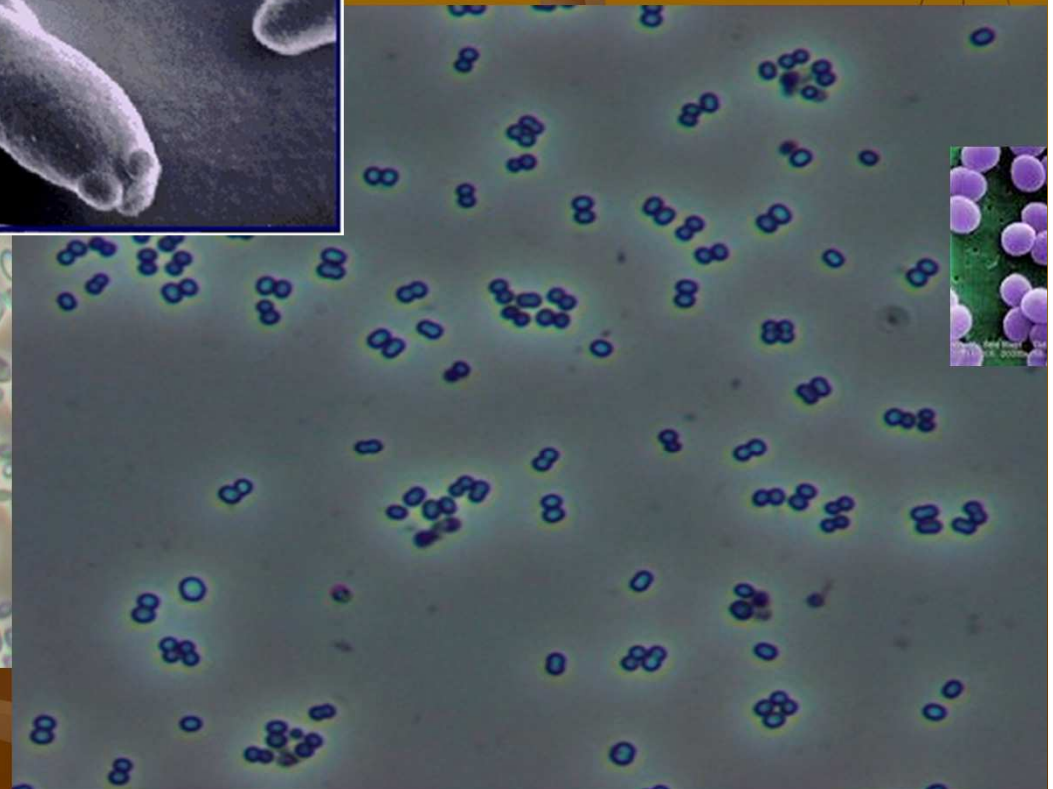
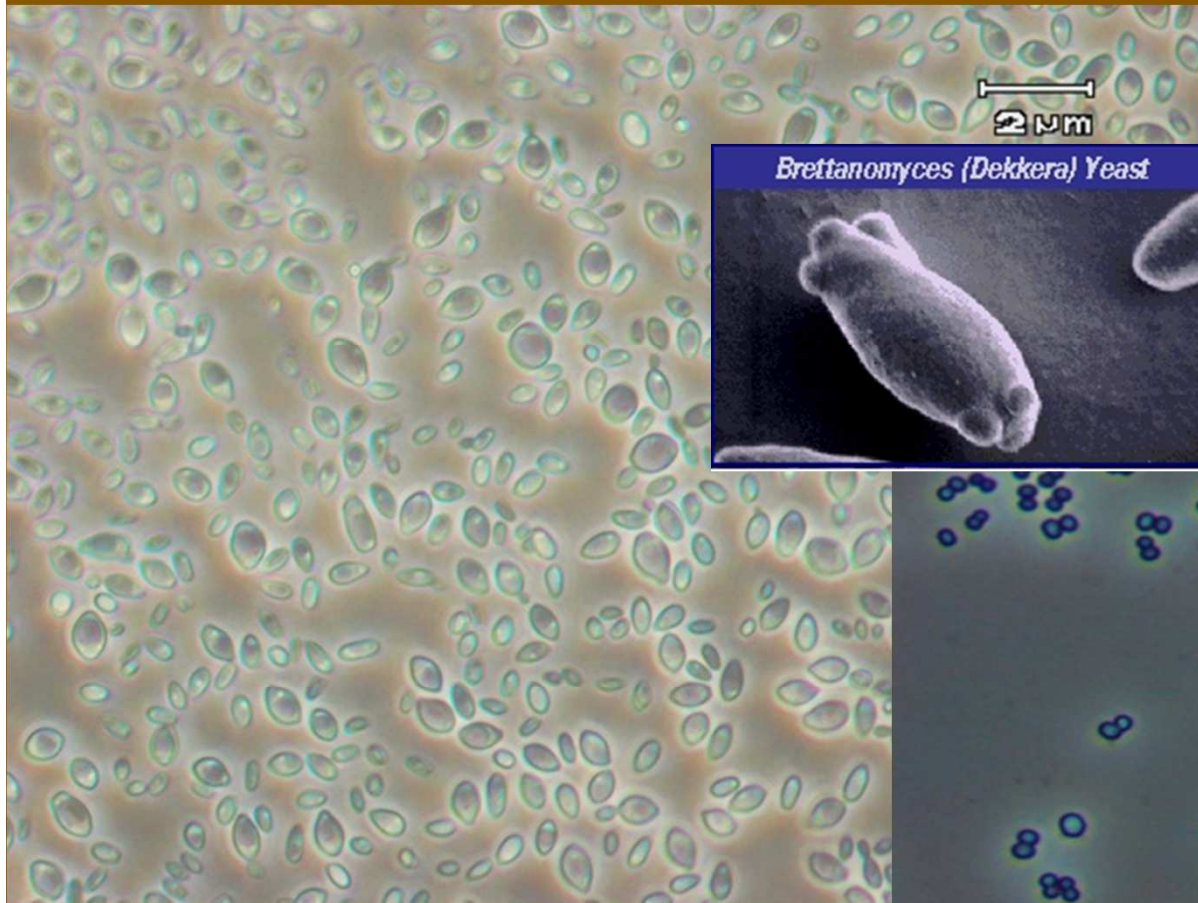
=***Brettanomyces(Dekkera) anomala***

Brettanomyces naardenensis

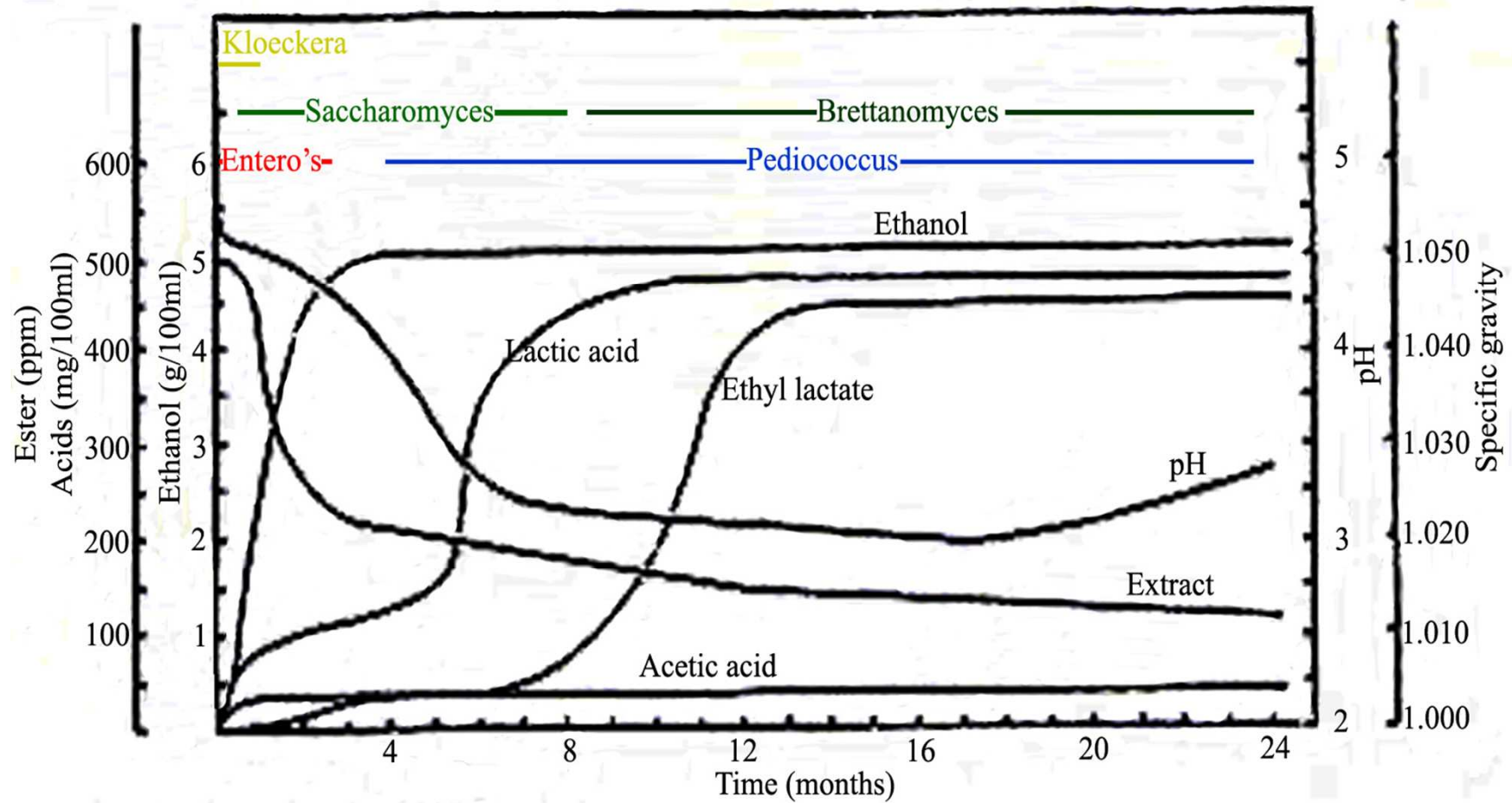
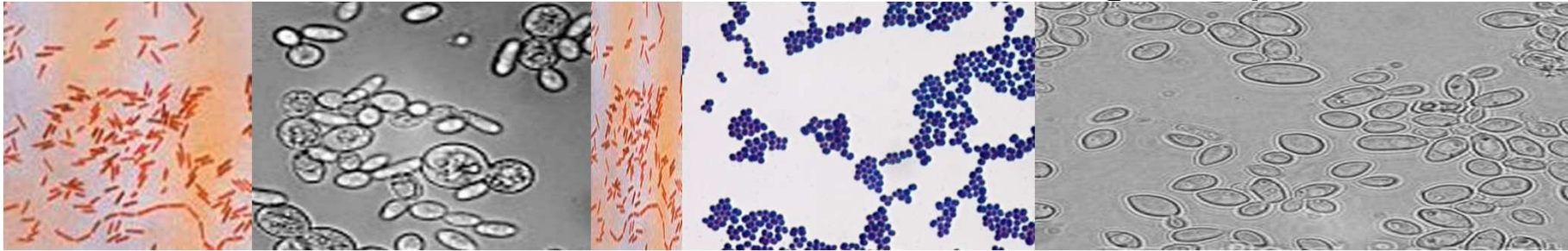
Brettanomyces custersianus

Brettanomyces nanus

The famous *Brettanomyces* and *Pediococcus*



Lambic fermentation microbiological profile



Comparison of different brewing and fermentation conditions

- ❁ METAL TANKS versus WOODEN CASKS
- ❁ INFUSION versus TURBID MASH BREWING
- ❁ FRESH versus OLD HOP / TURBID MASH
- ❁ FRESH versus OLD HOP / INFUSION
- ❁ DIFFERENT WORT AT SAME LOCATION
- ❁ SAME WORT AT 2 DIFFERENT LOCATIONS
- ❁ (data from G.Aerts/Kuleuven/Kaho)

Lambic characteristics determined during 18 months lasting fermentations

- ✂ **ENTEROBACTERIACEAE** (normally found /first weeks)
- ✂ **ACTIDIONE-RESISTANT YEASTS** (*Brettanomyces*)
- ✂ **NON ACT.-RES. YEASTS** (e.g. *Saccharomyces*)
- ✂ **LACTIC ACID BACTERIA**

- ✂ **ATTENUATION**
- ✂ **ETHANOL**
- ✂ **LACTIC ACID**
- ✂ **ACETIC ACID**
- ✂ **pH**
- ✂ **ETHYL LACTATE**
- ✂ **ETHYL ACETATE**

WHATEVER CONDITIONS EXAMINED :

Microbial Sequence in lambic fermentation

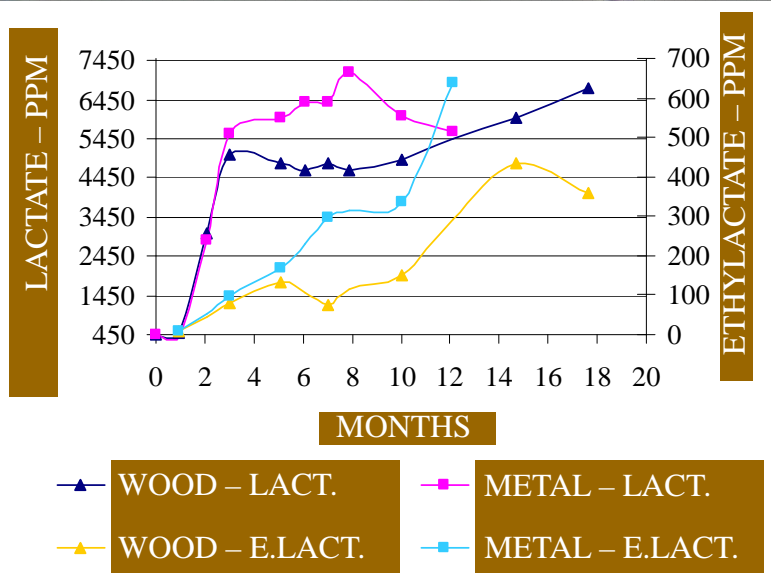
Enterobacteriaceae sp

Saccharomyces sp + *LAB sp*

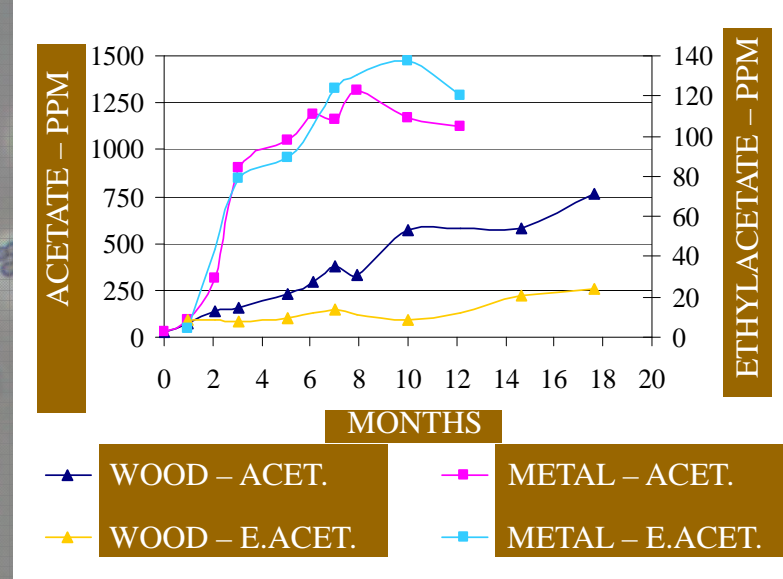
Brettanomyces sp + *LAB sp*

METAL TANKS versus WOODEN CASKS

Lactate (LACT) + ethyllactate (E.LACT)



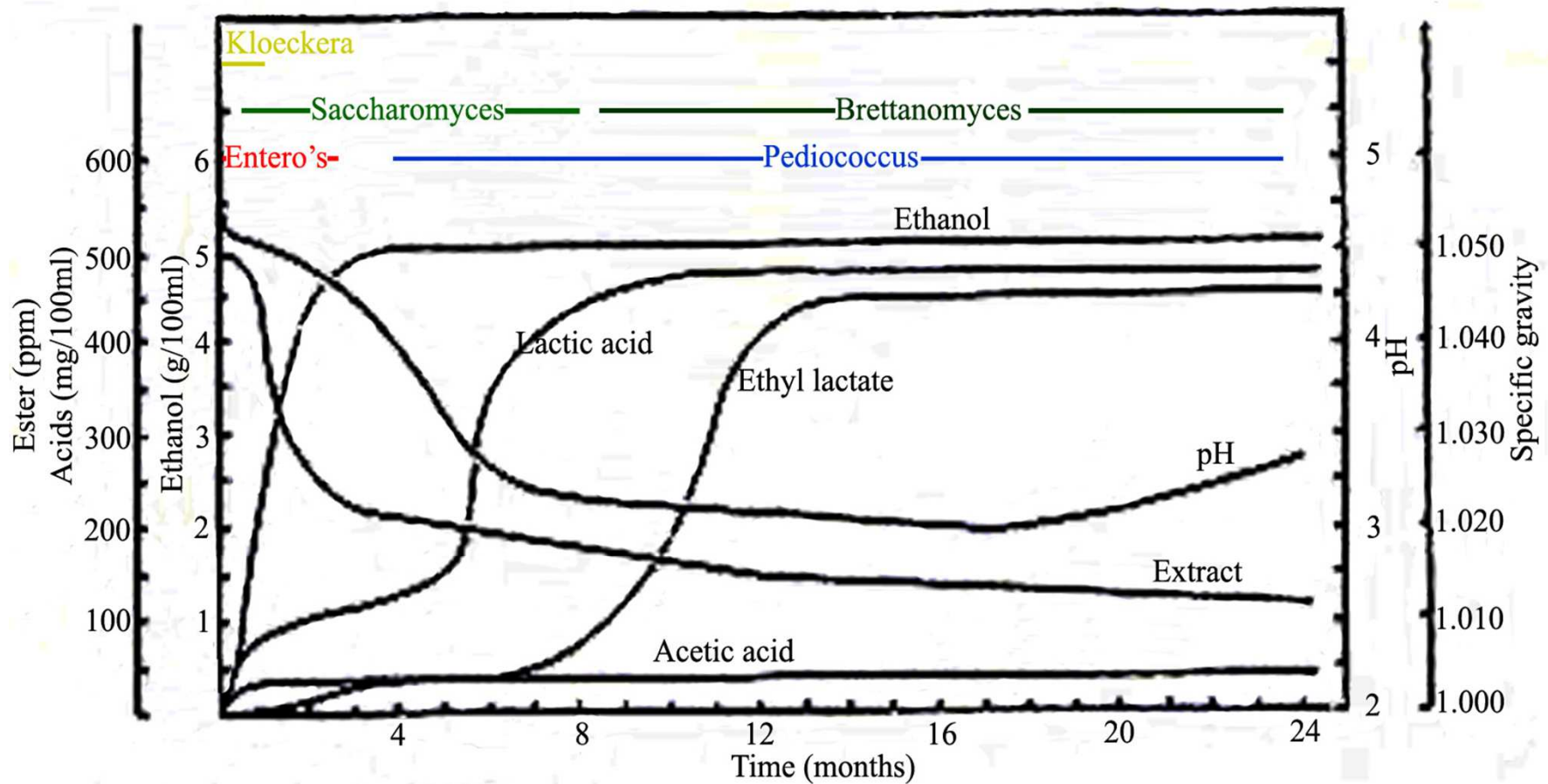
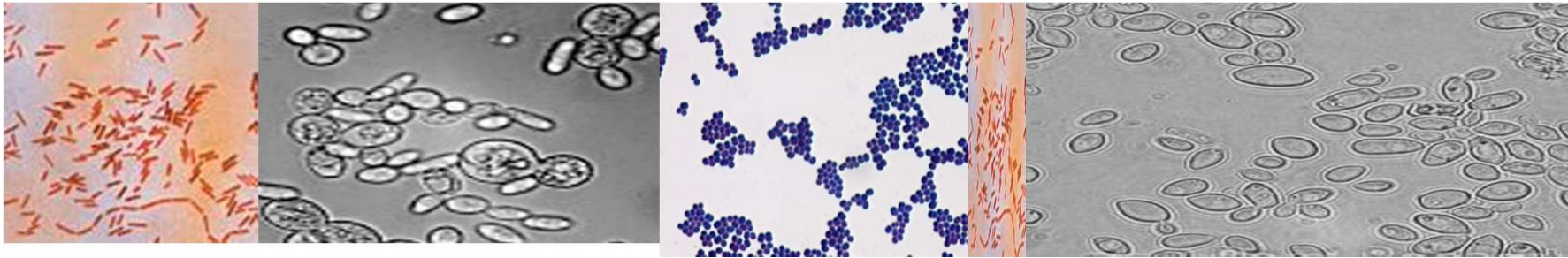
Acetate (ACET) + ethylacetate (E.ACET)



Turbid mash method / old hop / comparison between metal tank and wooden cask

		WOOD	METAL
Original extract	°P	9.8	9.8
Final attenuation (app)	%	93.1	97.2
Final attenuation (real)	%	74.4	78.6
pH		3.3	3.1

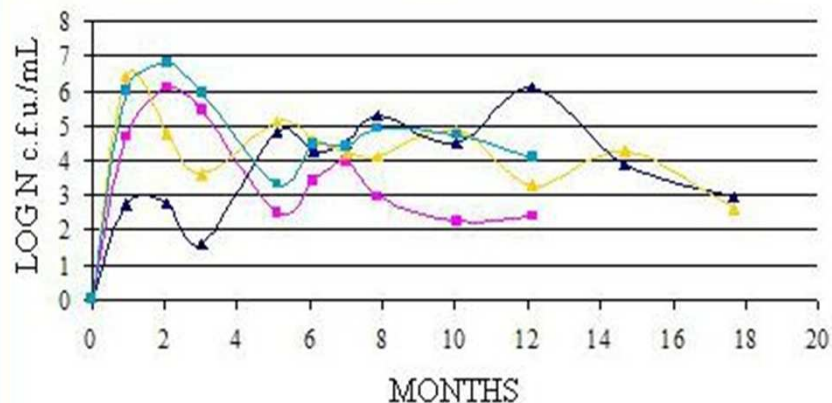
Lambic fermentation microbiological profile



Lambic fermentation: *Brettanomyces* type yeasts, actidione resistant

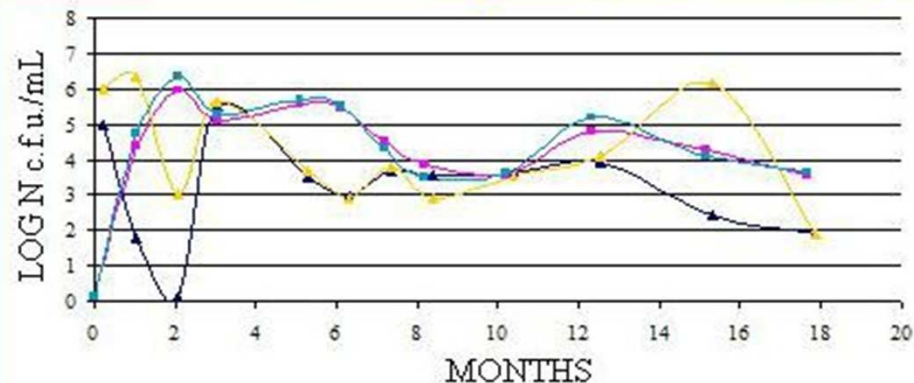
tanks: wood vs metal hops: fresh vs old

Actidione resistant yeasts (A. Res. Y.) + Non actidione resistant yeasts (Non A. Res. Y.)



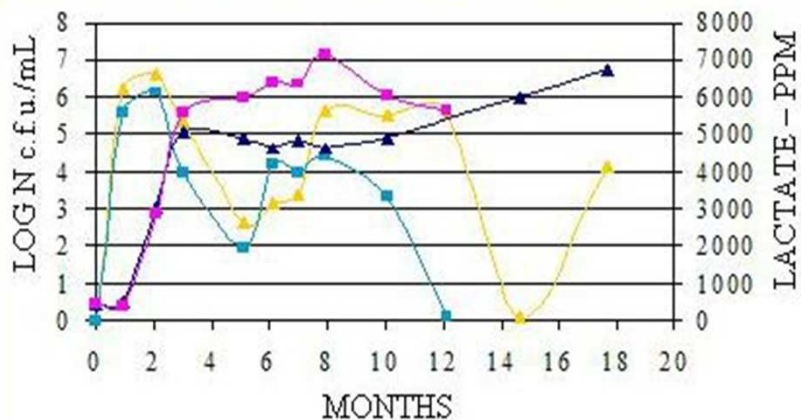
- ▲ WOOD - A. RES. Y.
- ◆ WOOD - NON A. RES. Y.
- METAL - A. RES. Y.
- METAL - NON A. RES. Y.

Actidione resistant yeasts (A. Res. Y.) + Non actidione resistant yeasts (Non A. Res. Y.)



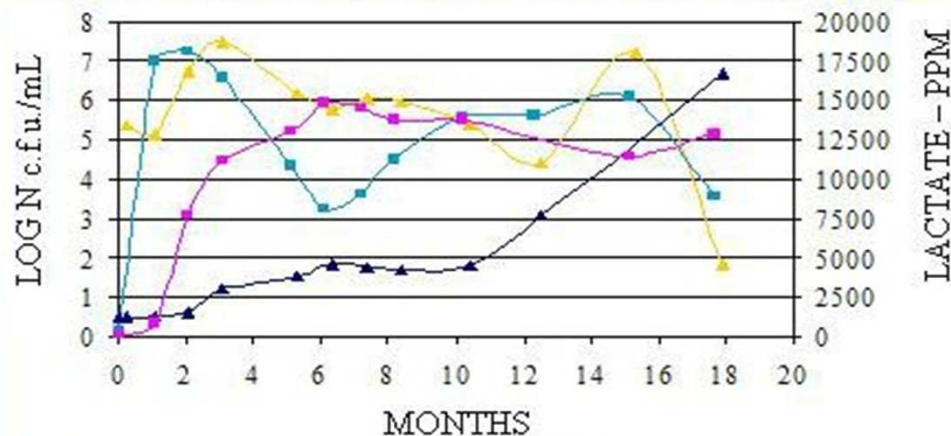
- ▲ T.M. - FRESH H - A. RES. Y.
- ◆ T.M. - FRESH H - NON A. RES. Y.
- T.M. - OLD H - A. RES. Y.
- T.M. - OLD H - NON A. RES. Y.

Lactate (LACT) + Lactic acid bacteria (LAB)



- ◆ WOOD - LAB.
- ▲ WOOD - LACT.
- METAL - LAB.
- METAL - LACT.

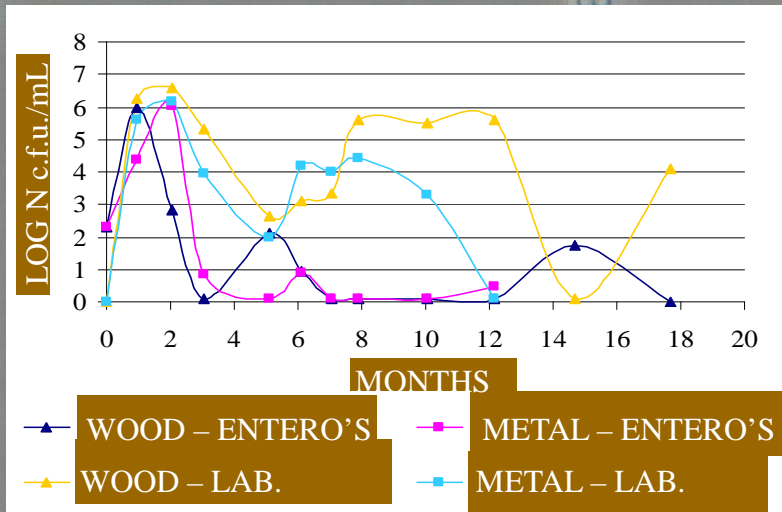
Lactate (LACT) + Lactic acid bacteria (LAB)



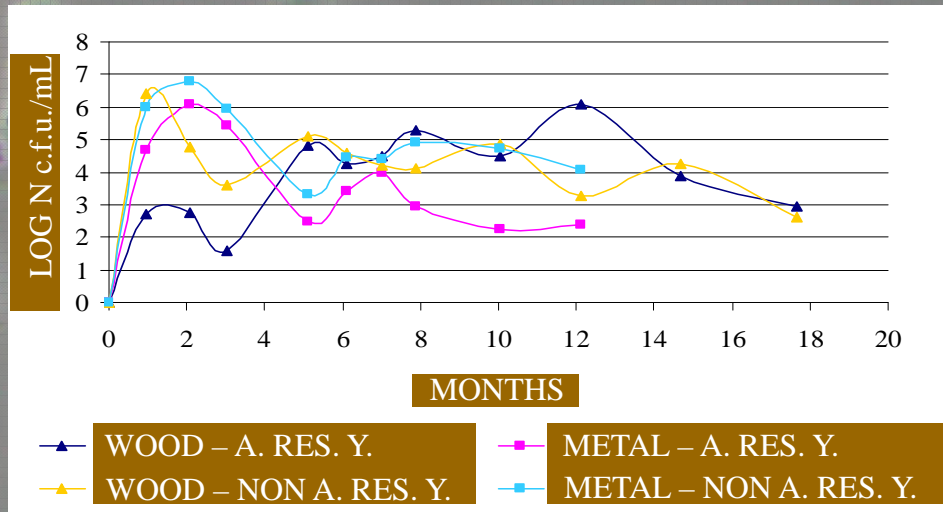
- ◆ T.M. - FRESH H - LAB.
- ▲ T.M. - FRESH H - LACT.
- T.M. - OLD H - LAB.
- T.M. - OLD H - LACT.

METAL TANKS versus WOODEN CASKS

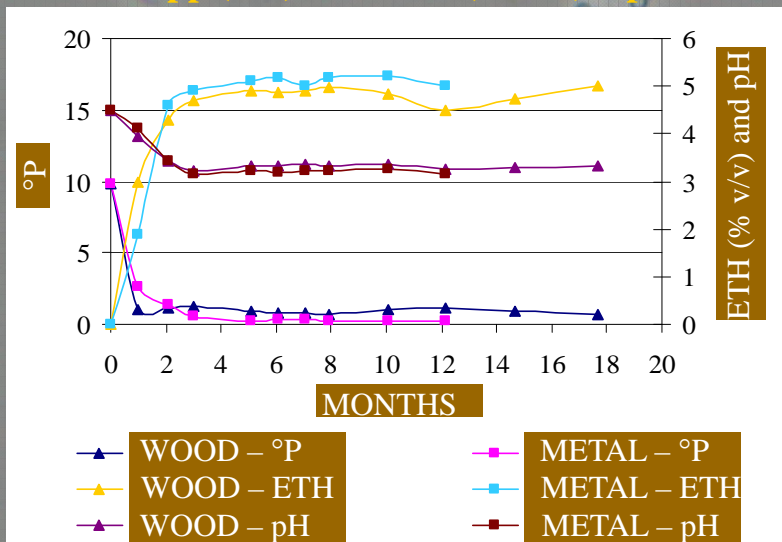
Enterobacteriaceae (ENTERO'S) +
Lactic acid bacteria (LAB)



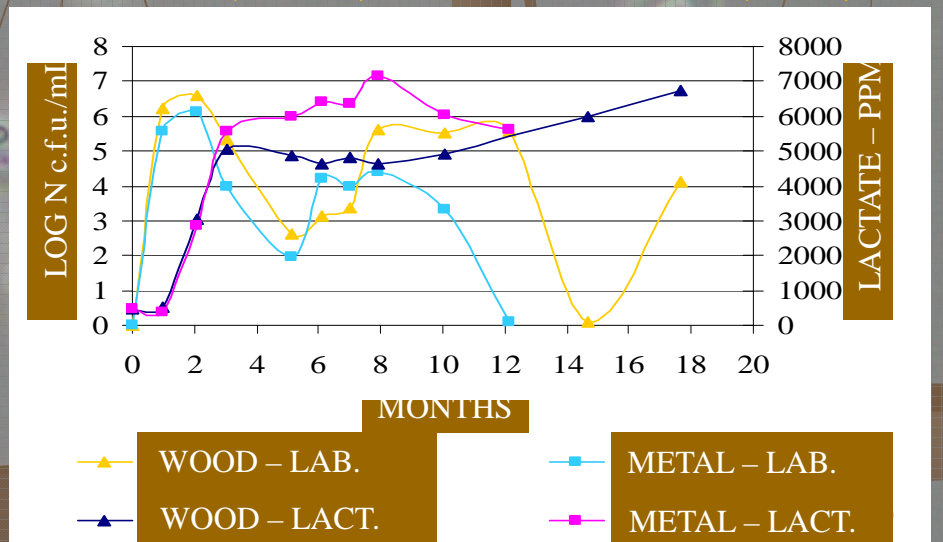
Actidione resistant yeasts (A. Res. Y.) +
Non actidione resistant yeasts (Non A. Res. Y.)



Eapp (°P) + ethanol (ETH) + pH

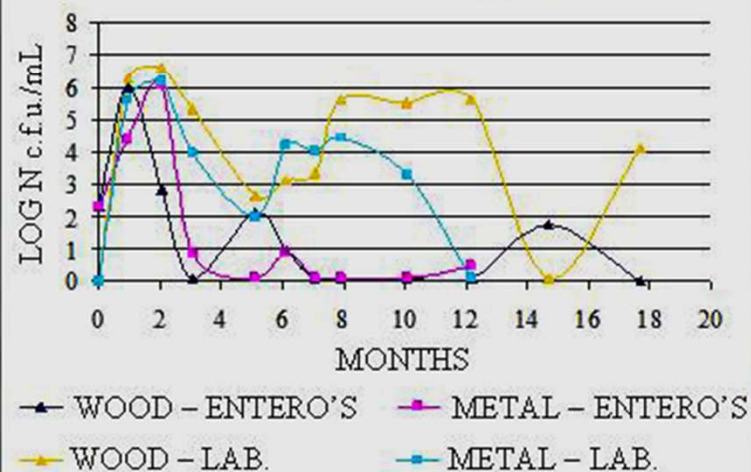


Lactate (LACT) + Lactic acid bacteria (LAB)

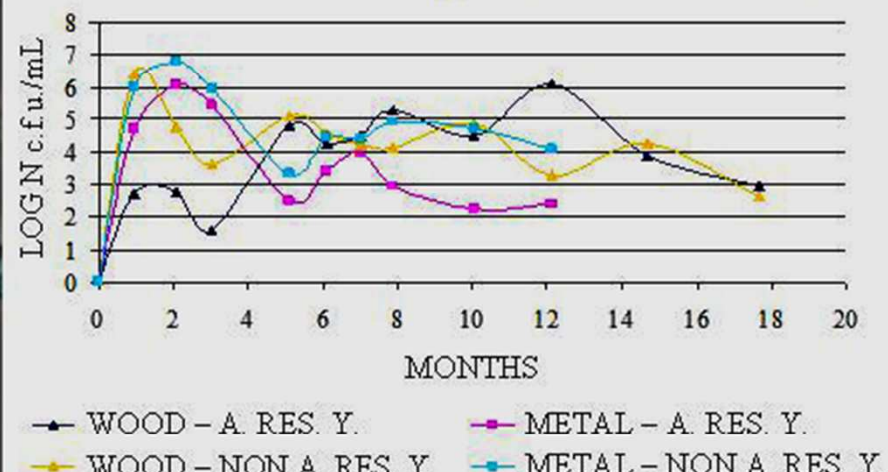


METAL TANKS versus WOODEN CASKS

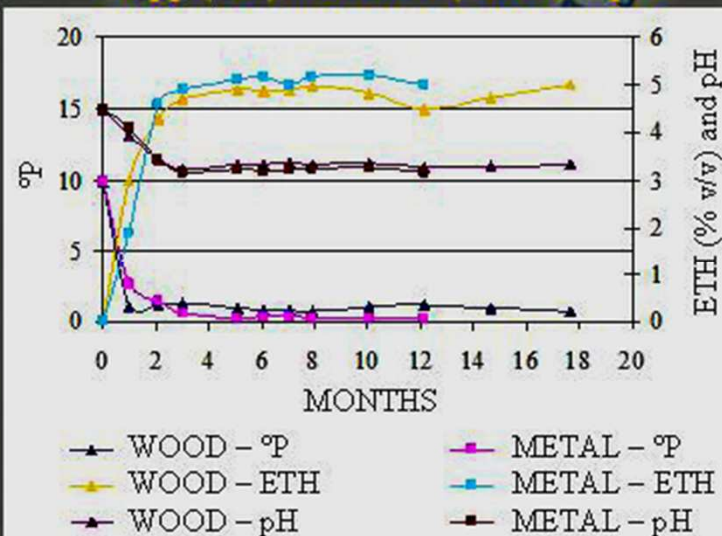
**Enterobacteriaceae (ENTERO'S) +
Lactic acid bacteria (LAB)**



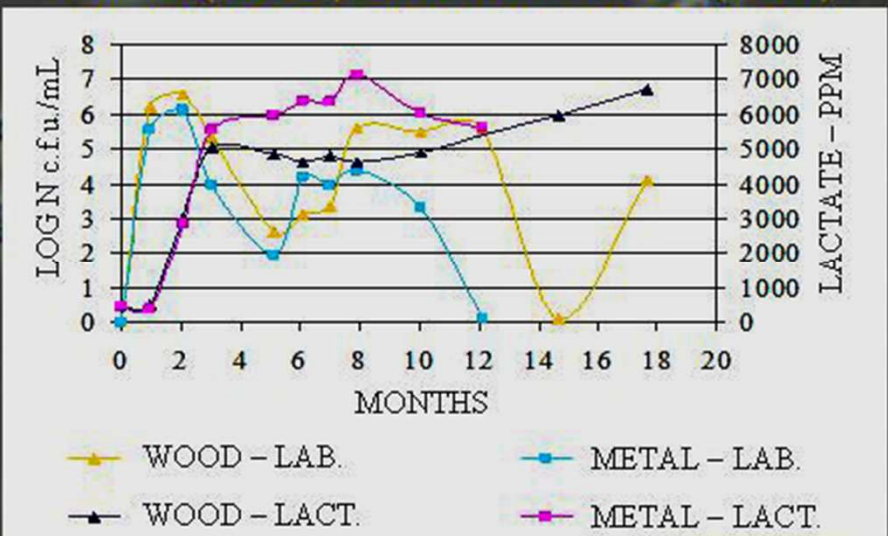
**Actidione resistant yeasts (A. Res. Y.) +
Non actidione resistant yeasts (Non A. Res. Y.)**



Eapp (°P) + ethanol (ETH) + pH



Lactate (LACT) + Lactic acid bacteria (LAB)



Under proper conditions

- **Lambic can be produced in metal tanks**



Under proper conditions

- **Fresh hops compared to aged hops were not detrimental to lambic brewing**



Under proper conditions



- **Infusion brewing compared to turbid mash brewing is possible**



Under proper conditions

- **Infected lambic worts from site A or B give a good similar cask fermenting lambic at site C**



Under proper conditions

- Seeded lambic wort at site **A** shows a similar behavior when cask fermented at different sites **a** or **b**



Spontaneous infected lambic wort from a brewery **A** is transferred to brewery **a** and **b** where it is only cask- and bottle fermented.

Or: the infected worts from brewery **A** and **B** is transferred to brewery **a**



OBSERVATIONS:

The cask environment has more final effects than the open trays environment

The steker gueuze has its own characteristics.

Bottle refermentation scheme

CLASSIC BOTTLE REFERMENTATION

YOUNG FINISHED BEER

ADDITION OF SUGAR + YEASTS

BOTTLING

INCUBATION

REFERMENTED BEER

TRADITIONAL LAMBIC BOTTLE REFERMENTATION

OLD LAMBIC
(enzymes + micro-organisms)
MIXED WITH YOUNGER
LAMBIC (substrates)

BOTTLING

INCUBATION

GUEUZE (« FOND GUEUZE »)



Experimental conditions to study bottle refermentations

4 MOTHER LAMBICS

A - 20 months (0.95°P) **D** - 20 months (2.28°P)
B - 12 months (3.10°P) **F** - 20 months (1.99°P)

AND

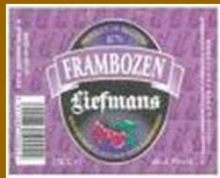
10 DIFFERENT MICROBIAL INOCULATIONS

	A	B	C	D	E	F	G	H	I	J
<i>Brettanomyces bruxellensis</i>	X				X		X			
<i>Brettanomyces lambicus</i>		X				X		X		
<i>Saccharomyces cerevisiae</i>			X							
<i>Saccharomyces bayanus</i>				X			X	X		
<i>Pediococcus</i> (2 strains)					X	X				X
<i>Brettanomyces</i> (isolated, 2 strains)									X	X

Other gueuze beers



1. Filtered gueuzes: lambic
pasteurized, not-
referred, carbonated (sweetened)



2. Fruit beers: As above but
mixed (diluted) with fruit juices. (Not
always with lambic)



3. Kriek gueuze: cask-fermented
with added sour cherries and
referred: The real thing!



FARO

much preferred sweetened version of lambic



Faro from **latin** *far*: a type of wheat

Faro is a blend of old strong lambic and a less strong version. The blending is traditionally done by the inn-keeper or later by the brewer or

a »préparateur«, an intermediate between brewer and inn-keeper

Anyhow the blend is **sweetened** by the **inn-keeper** by adding dark concentrated lambic wort syrup or later candy sugar. The préparateur in general may clarify, colour and sweeten the faro blends....



Preferential sweetening of acidic beers

Faro is a lambic locally sweetened by pub holders
Sweetening can also be an individual preference. An
individu is then provided with sugar and a crusher
("stoemper") This practice was also common for other
acidic beers such as Aarschotse bruine etc.



2. Acidification by blending an ale with lambic or gueuze

JACK-OP !!!



A successful acidic beer around 1920, brewed in Werchter, called the students beer, is a BLEND of a top fermented ale and a lambic or gueuze.

A similar process was used for Aarschotse bruine which has recently been re-introduced.

Are white beers acidic ?

Verlinden in 1944 described our white beers to contain around 2000 ppm acid (as lactic acid) **NOW** in contrast to the German Berliner Weisse **(+mixed cultures)**

the Belgian white beers **(+pure cultures)** are **not really sour**

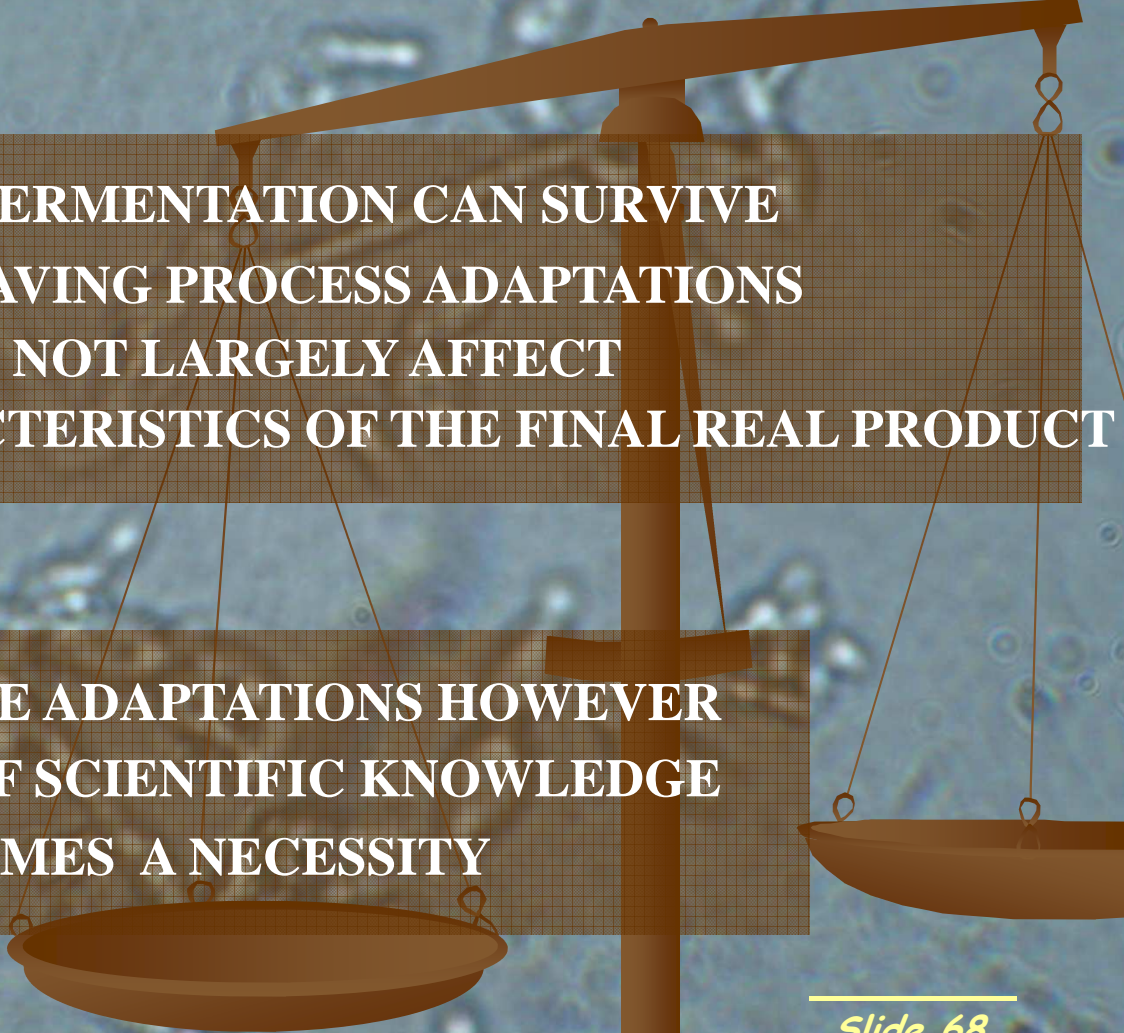
(although drinkers may appreciate sourness by adding a slice of lemon!)

A so called **white lambic** on the contrary can be appreciated by its charming low acidity

**Lambic wort+spices--spontaneous fermentation--
young lambic--carbonatation--bottling--
pasteurisation**



THE FUTURE OF LAMBIC AND GUEUZE



SPONTANEOUS FERMENTATION CAN SURVIVE
BY USING TIME SAVING PROCESS ADAPTATIONS
WHICH DO NOT LARGELY AFFECT
THE REQUIRED CHARACTERISTICS OF THE FINAL REAL PRODUCT

FOR RELIABLE ADAPTATIONS HOWEVER
A MINIMUM OF SCIENTIFIC KNOWLEDGE
BECOMES A NECESSITY

Acidic beers

*Belgian red and brown
sour ales*

Non gueuze TYPES OF ACID BEERS ANNO 2012

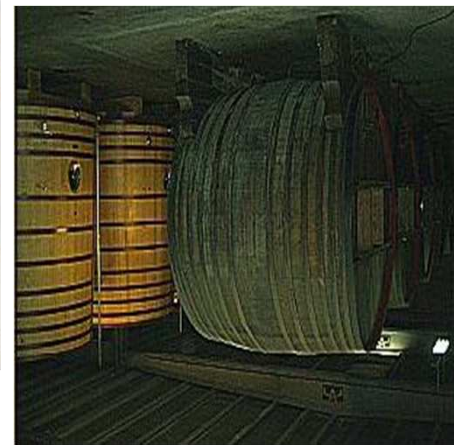
The regional Flandres acid ales

type Rodenbach....



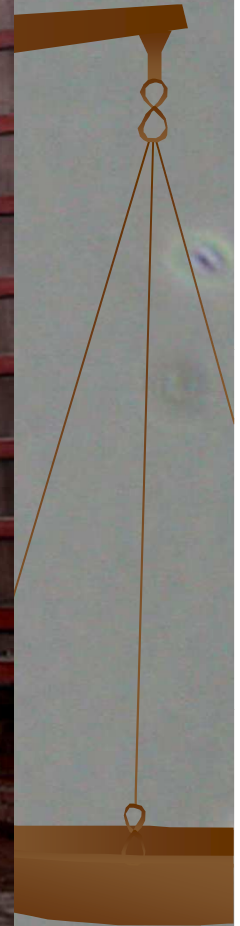
Rodenbach, Liefmans, Petrus, Bacchus, Bourgogne des Flandres, Duchesse de Bourgogne...

Red-brown Flandres acidic beers fermented in barrels or metal tanks.

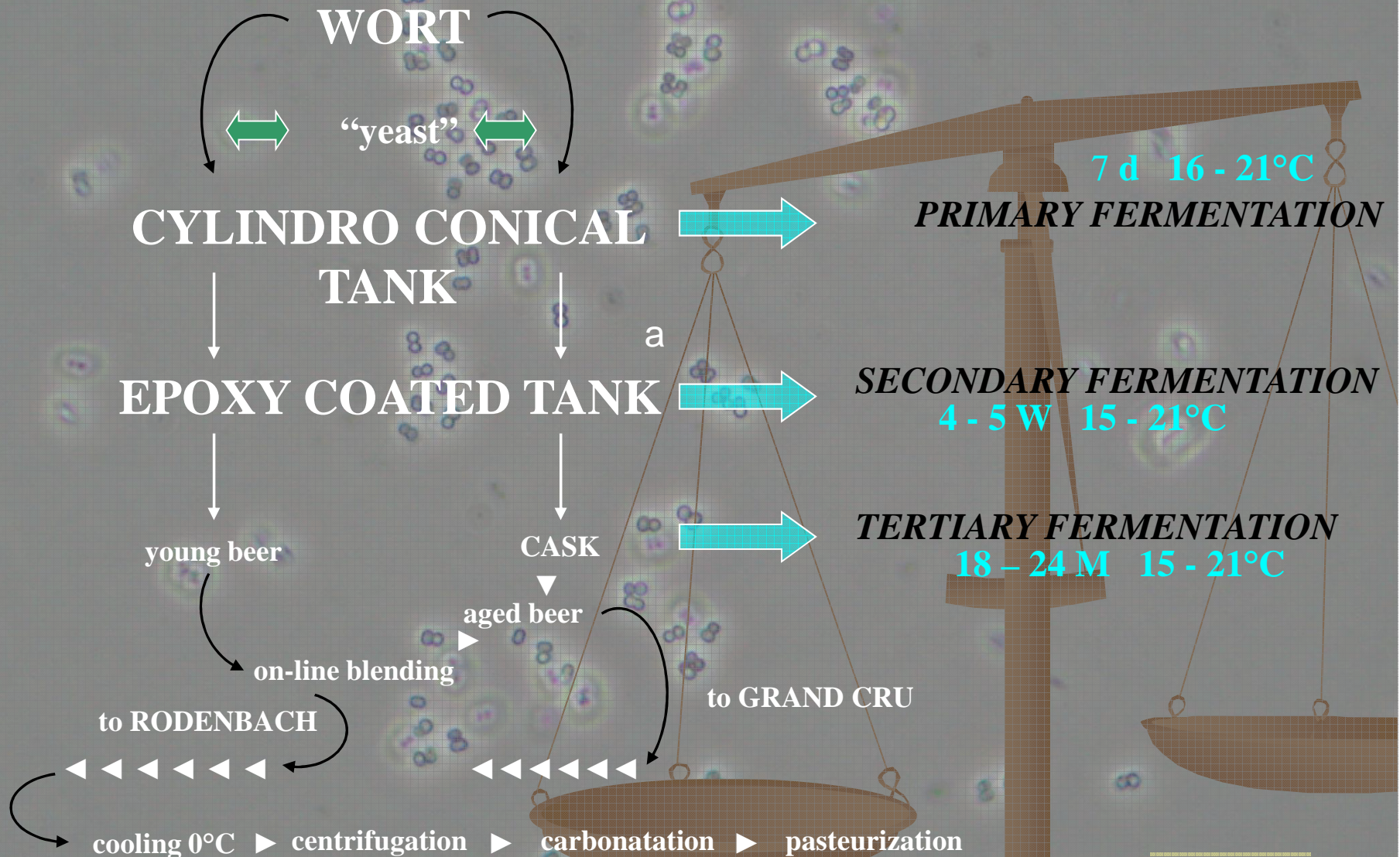


1. Flanders' red-brown beer : Rodenbach

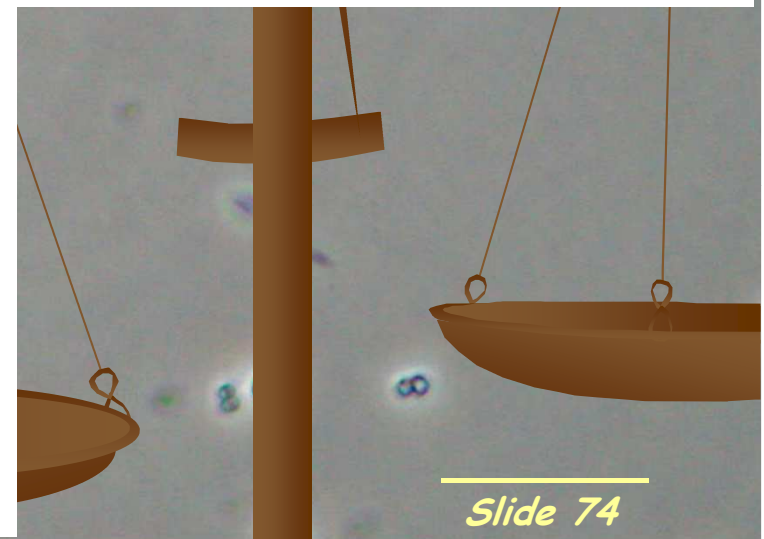
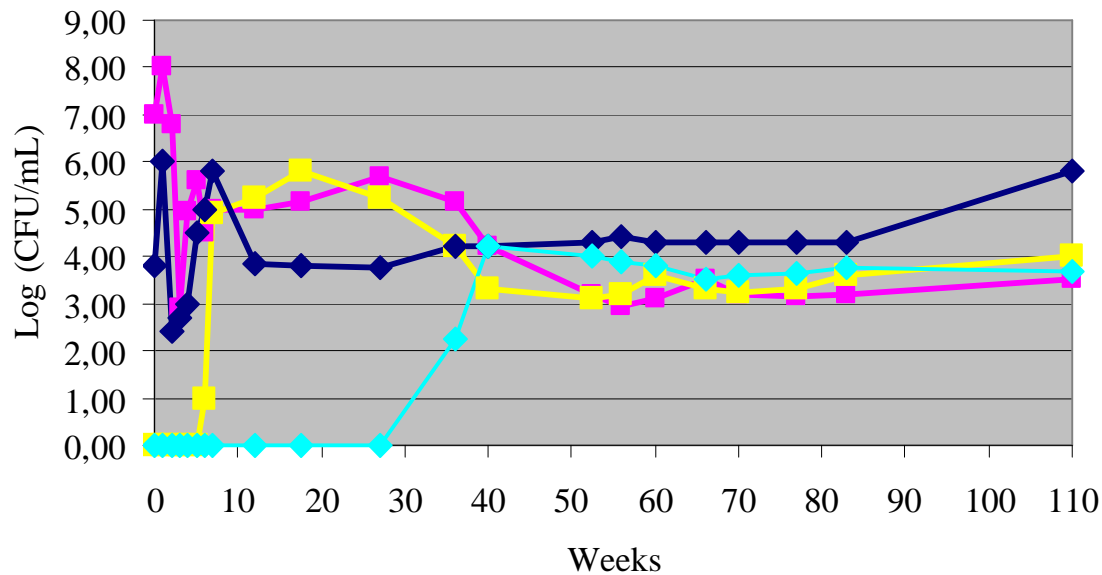
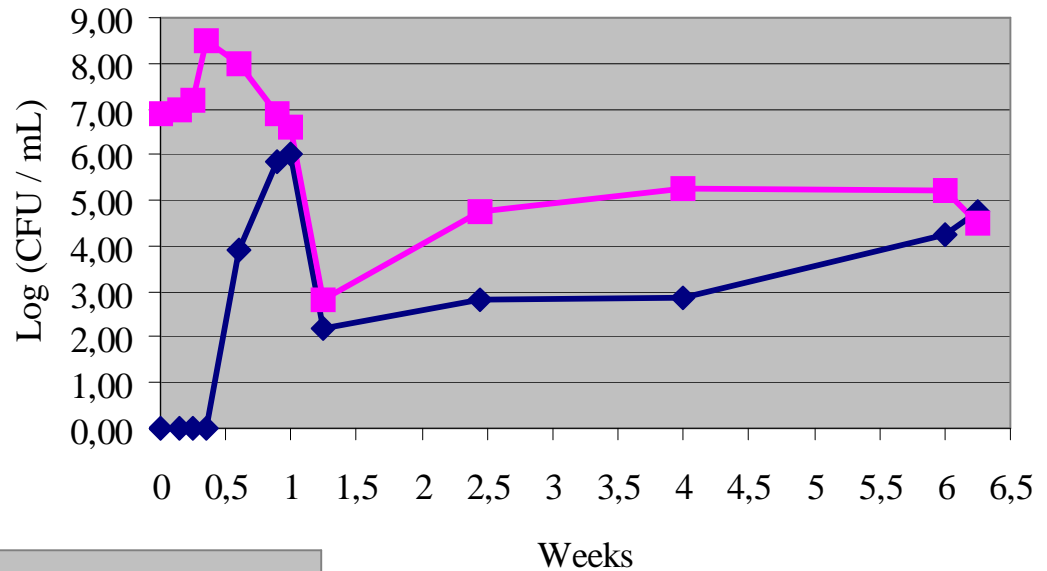
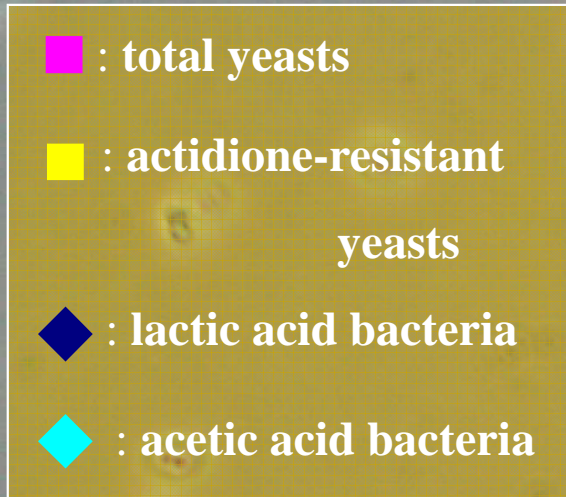
Large wooden casks



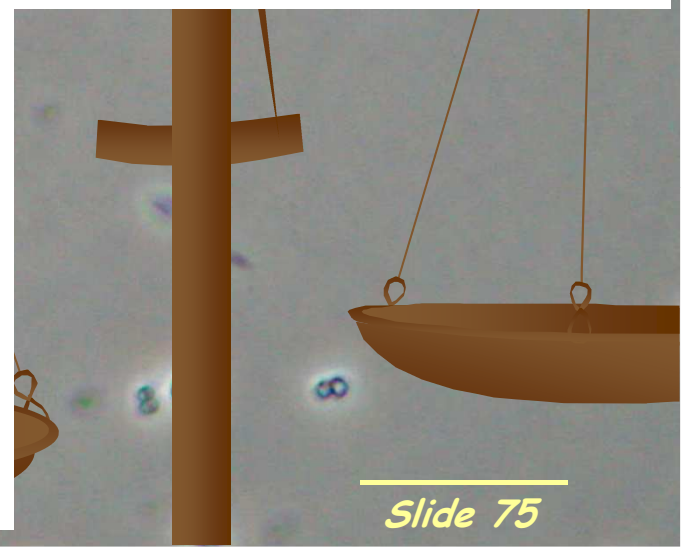
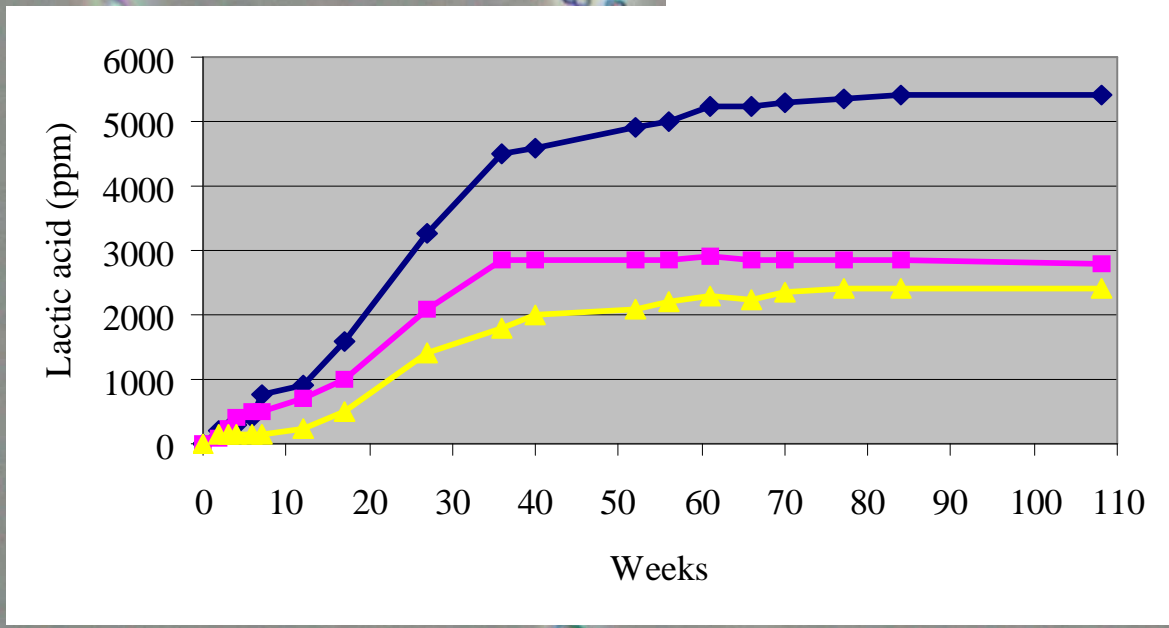
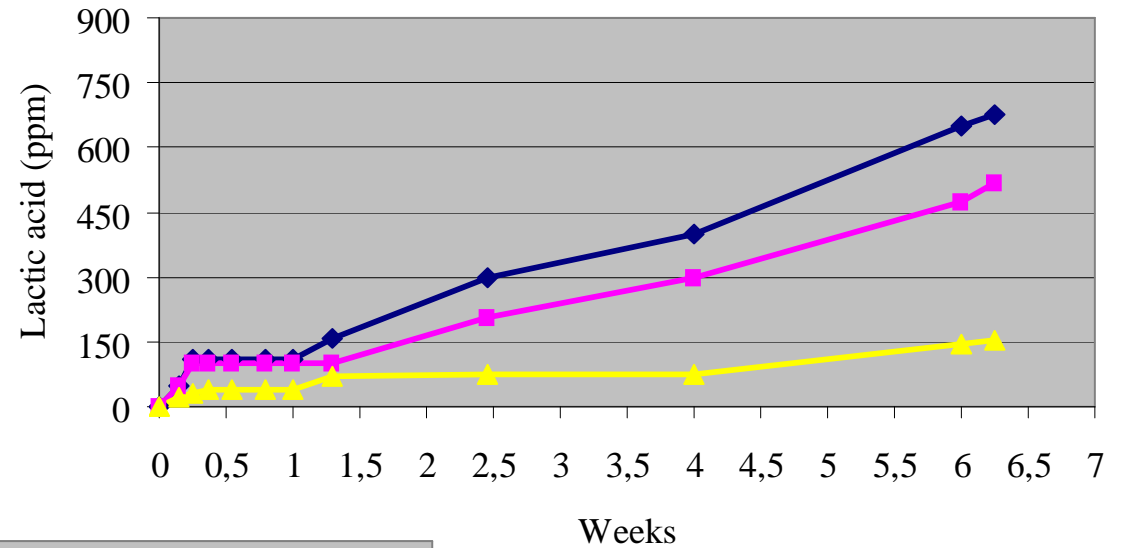
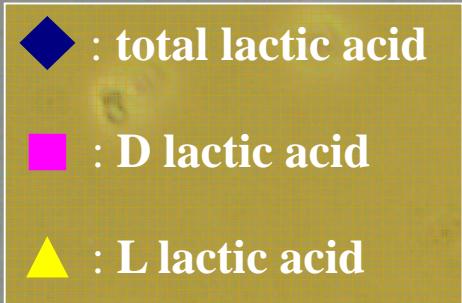
Rodenbach beer fermentation steps



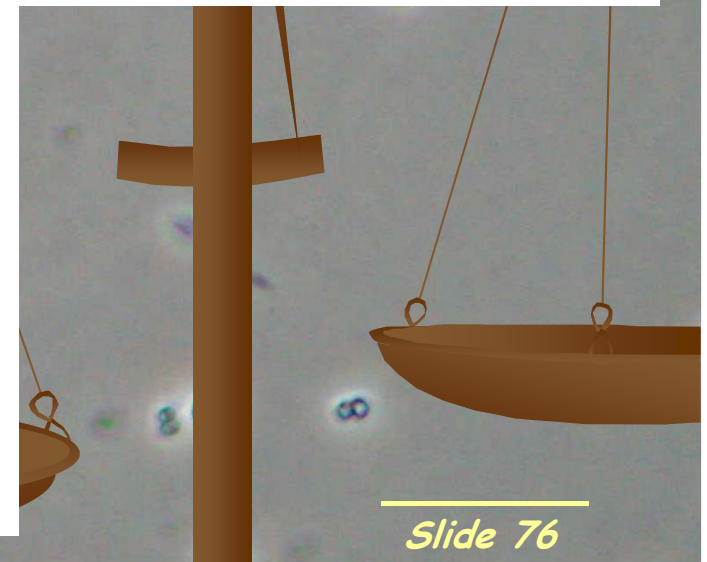
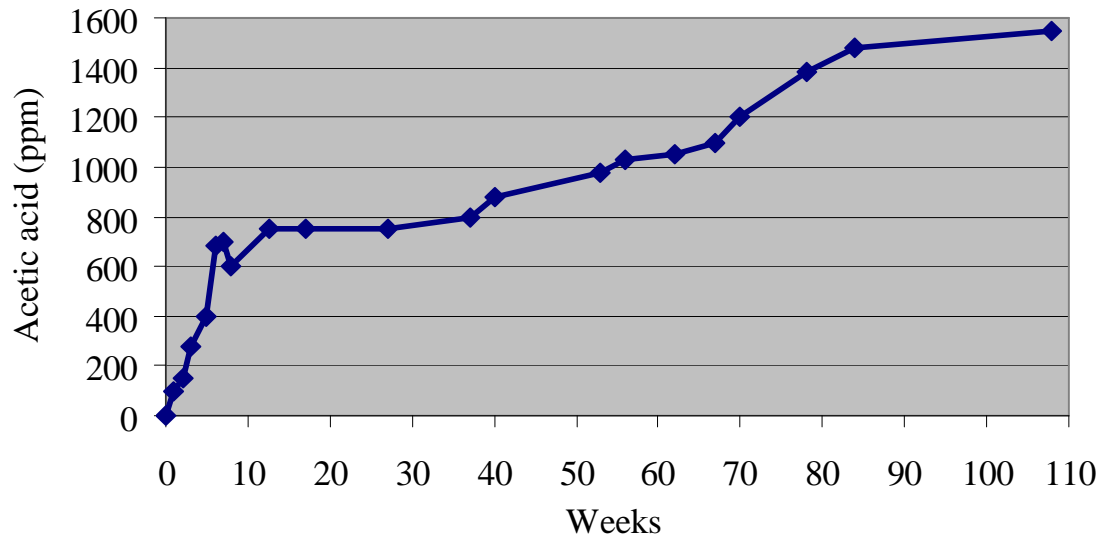
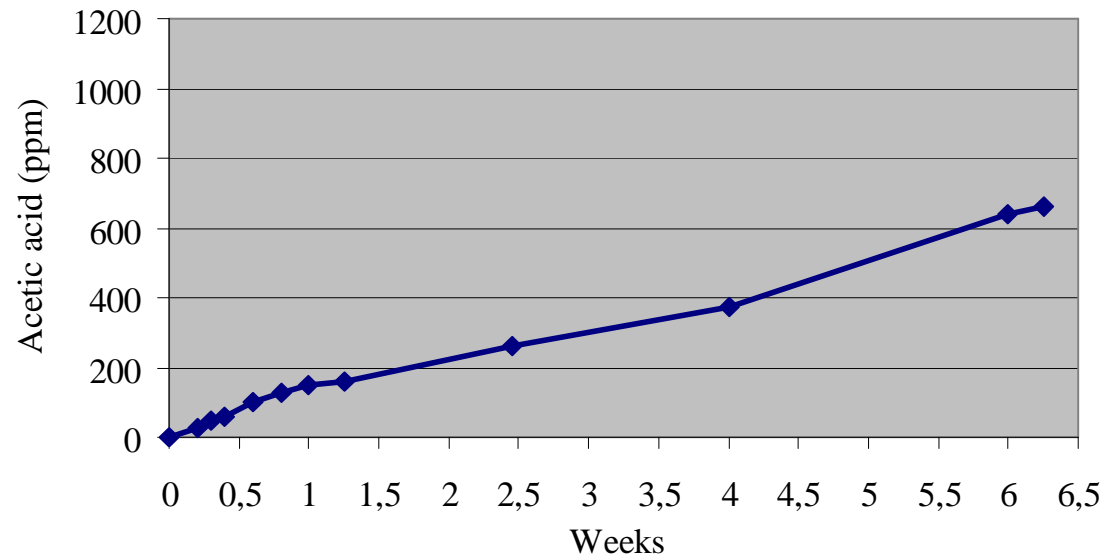
Evolution of microbial populations of Rodenbach fermentation



Evolution of lactic acid during Rodenbach fermentation



Evolution of acetic acid during Rodenbach fermentation



CONCLUSIONS

The renewed appreciation for high quality
gueuzes and sour ales proves that
traditional processes

CAN survive modern times provided that
the brewer is prepared for

HARD WORK , incomparable **enthusiasm**
for the final product and **awareness** and
understanding of possible scientific progress.

TYPES OF ACID BEERS ANNO 2009

- ❁ BERLINER WEISSBIER (Germany)



Goslar/Leipzig beer

Spontaneous fermented acidic
beer around 1740

Cask fermentation achieved in
long neck bottles

Bottles closed by yeast
crop, not corked !

